International Journal of Engineering and Applied Sciences (IJEAS)
ISSN: 2394-3661, Volume-2, Issue-6, June 2015

River Morphology and Riparian Vegetation at the Tributary of Seongdong, Korea

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Abstract— **The purpose of this study is to investigate river morphology, riparian vegetation, and water quality on the tributary of Seongdong River in Korea during four seasons. There were not significant differences for river structure according to the river morphology and river naturality according to the environment of river at three regions (upper, middle and low areas). The portion of BOD and COD in the river increased exponentially along the upper-down gradient. The surveyed region was a total of 57 taxa, including 23 families, 50pecies, and 7varieties. Naturalized plants were 18species.**

Index Terms— **Seongdong River, river morphology, riparian vegetation.**

I. Introduction

Water of sufficient quality and quantity is critical to all life. Increasing human population and growth of technology require human society to devote more and more attention to protection of adequate supplies of water [1].

Worldwide, agriculture claims about 69 percent of total water withdrawal, ranging from 93 percent of all water used in India to only 4 percent in Kuwait, which cannot afford to spend its limited water on crops [2].

Aquatic plants are organisms that have adapted to living in aquatic environments (saltwater or freshwater). They are also referred to as hydrophytes or macrophytes. These plants require special adaptations for living submerged in water, or at the water's surface - the most common adaptation is aerenchyma, but floating leaves and finely dissected leaves are also common [3, 4, 5].

Rapid population growth has already increased aggregate water demand to the point that it exceeds the available water supply in some years. Increases in water resources development and utilization over the last 40 years have led to significant environmental and hydrological degradation in many Korean rivers [6]. Most agricultural and urban land use practices, reduced water quality [7].

The purpose of this study is to investigate river morphology and the flora on the tributary of Seongdong River at three regions. Therefore, this survey recorded material significance for the future appears in the environment to restore or improve the problem may be.

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II. Materials and Methods

2.1 Surveyed regions

Geographical ranges of the tributary of Seongdong River were a total length of 600 meters from mountains to the confluence of the Seongjeong River. This study was carried out on the tributary of Seongdong River, located at Jinhae province (upper region: 35°115′016″N/128°836′367″E, low region: 35°115′220″N/128°838′446″E), in Korea (Fig. 1). In this region, the mean annual temperature is 14.9℃ with the maximum temperature being 26.5 ℃ in August and the minimum 2.8℃ in January. Mean annual precipitation is about 1545.4 mm.

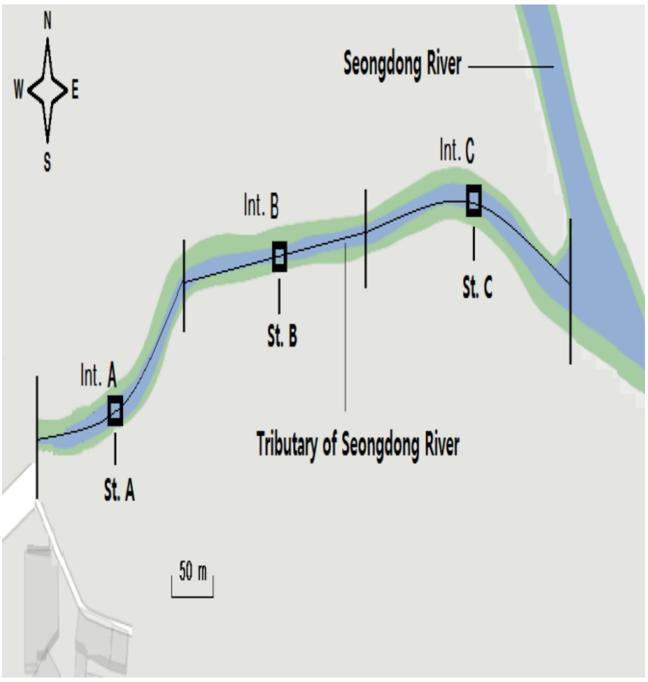

Figure 1: The three surveyed sections for river morphology and three surveyed sites for water quality at the tributary of Seongdong River.

2.2. Index of degree of river structure and identification of species

The tributary of Seongdong River were divided by the geographic location with considering length of the river. Index of degree of river structure according to the river morphology was analyzed according to Table 1. Index of degree of river naturality according to the environment of river was also analyzed according to Table 2. River terminology was followed by Hutchinson [8]. All plants of riparian vegetation were identified. The system of plant

classification system was followed by Lee [9]. Naturalized plants were followed by Korea National Arboretum [10].

2.3. BOD and COD measurements

Laboratories and equipment were used to measure a range of water quality parameters including pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD). DO and pH were measured with YSI field meters (Professional Plus, Geotech, Colorado, USA). The test for biochemical oxygen demand (BOD) is a bioassay procedure that measures the oxygen consumed by bacteria from the decomposition of organic matter [11]. The method for BOD was used to a standard method of the American Public Health Association (APHA) and is approved by the U.S. Environmental Protection Agency (USEPA) [12]. COD is a widely known parameter used to measure water quality using the 910 colorimeter (YSI Incorporated, Ohio, USA).

2.3. Environmental factors

An ecological distance describes the difference in species composition [13. The relationship between a distance matrix and a quantitative environmental variable can be analyzed with Mantel test.

III. Results

3.1. Upper region

The river width at this region is about 2.5 m. Transition zones of this section were distributed pine vegetation and chestnut communities. Riverbed area was dominated by the distribution of the willow communities. The left area in the river was a waterfront park and right areas were roads and a residential. Number of flexion was one in this region (Table 3). Transversal and longitudinal sandbar was one. Velocity of flood was fast. Bed materials were composed of boulders and gravel. Diversity of low channel width was slight. Materials of river shore at low channel width were natural materials and artificial vegetation. Materials of river levee at low channel width were composed of natural state. Mean score for river naturality according to the river morphology was 2.71. The law water's edge vegetation was natural vegetation (Table 4). The flood way vegetation was natural formed various vegetation communities. Land use in riparian zones within river levee was bush or grasses. Transverse direction of artificial structures was absent. The ratio of sleep width/river width was 23%. *Pinus densiflora* and *Pinus rigida* were dominantly distributed in riparian around. *Salix gracilistyla* was distributed in riparian. The survey region was a total of 28 taxa, including 20 families, 26 species, and two varieties. Naturalized plants were five species. The value of pH was 7.55 (Fig. 2). The average values of BOD and COD four seasons were 4.51 mg/l and 5.16 mg/l, respectively.

3.2. Middle region

The river width at the region is about 3.0 m. The flexion was not found in middle region (Table 3). Transversal and longitudinal sandbars were none. Velocity of flood was slight. Bed materials were composed of sand, silt, and clay (50% >). Diversity of flow was fast. Diversity of low channel width was moderate. Materials of river shore at low channel width were composed of natural materials and artificial vegetation. Materials of river levee at low channel width were artificial soil levee. Mean score for river naturality according to the river morphology was 3.14. The law water's edge vegetation communities were natural weeds, shrubs and mixed (Table 4). The flood way vegetation was shown both of natural vegetation and artificial vegetation. Land uses in riparian zones were arable land (paddy fields, orchards). Transverse direction of artificial structures was absent. The ratio of sleep width/river width was 10-20%. *Miscanthus sacchariflorus* was dominant species in the slope regions of the riverbanks. There were occurred in *Erigeron annuus*, *Erigeron canadensis*, *Persicaria hydropiper*, *Persicaria nodosa*, *Rumex crispus*, *Chenopodium album* var. *centrorubrum*, *Oenothera odorata*, *Lepidium apetalum*, *Vicia angustifolia* var. *segetilis*, and *Trifolium repens* (Table 5). The survey region was a total of 30 taxa, including 11 families, 27 species, and 3 varieties. Naturalized plants were 11 species. The value of pH was 7.61 (Fig. 2). The average values of BOD and COD four seasons were 50.1 mg/l and 5.57 mg/l, respectively.

3.3. Low region

The river width at the region was about 4.0 m. The sand dune areas were very widely developed in this region. Farmland is widely distributed in outsides of banks. Number of flexion was one in this region (Table 3). Transversal and longitudinal sandbar was absent. Velocity of flood was slight. Bed materials were composed of silt and clay. Diversity of low channel width was large. Materials of river shore at low channel width were concreted impervious which was not penetrating structure. Materials of river levee at low channel width were composed of impervious levee with concrete. The law water's edge vegetation was vegetation blocked by stonework (Table 4). The flood way vegetation was natural formed various vegetation communities. Land use in riparian zones within river levee was state of nature without artificial vegetation. Transverse direction of artificial structures was absent. The ratio of sleep width/river width was 10~20%. There were occurred in *Rumex acetosa*, *Rumex conglomeratus*, *Ranunculus japonicus*, and *Trifolium pratense* (Table 5). The surveyed region was a total of 25 taxa, including 11 families, 21 species, and 4 varieties. Naturalized plants were 12 species. The value of pH was 7.63 (Fig. 2). The average values of BOD and COD four seasons were 5.43 mg/l and 6.34 mg/l, respectively.

The Bray-Curtis' distances were calculated from differences in abundance of each species according to geographic distances among three stations at the tributary of Seongdong River (Table 6). Neighboring stations such as St. B and St. C had the similar species composition and the highest remote populations (St. A and St. C) shares only some species.

Table 1. Index of degree of river structure according to the river morphology

Item	Estimated index and scores				
	1	2	3	4	5
No. of flexion	Over four	Three	Two	One	Absent
Transversal & longitudinal sandbars	Over 7	Five or six	Three or Four	One or two	Absent
Diversity of flow	Very fast	Fast	Moderate	Slight	Absent
Bed materials	Boulders	Boulders & gravel	Sand, silt, clay : 50% >	Silt, clay	Sand
Diversity of low channel width	Very large	large	Moderate	Slight	Absent
Materials of river shore at low channel width	State of nature without protecting materials	Natural materials + artificial vegetation	Stonework + artificial vegetation	Stonework or penetrating river shore	Concreted impervious
Materials of river levee at low channel width	State of nature without artificial levee	Artificial soil-levee (natural vegetation, lawn)	Stonework, natural type block with artificial vegetation	Stonework, penetrating levee with natural type block	Stonework, impervious levee with concrete

Table 2. Index of degree of river naturality according to the environment of river

Item	Estimated index and scores				
	1	2	3	4	5
The law water's edge vegetation	Naturally formed a variety of vegetation communities	Naturally formed various vegetation communities by natural erosion (sediment exposure) were absent	Natural weeds, shrubs, and mixed	Artificial vegetation composition	Vegetation blocked by stonework etc.
Flood way vegetation	Naturally formed a variety of vegetation communities	Naturally formed various vegetation communities by natural erosion (sand bar) were absent	Both of natural vegetation and artificial vegetation	Artificial vegetation with Parks, lawns, and so on	Remove vegetation artificially
Land use in riparian zones within river levee	Bush or grassland as natural floodplain	Arable land (paddy fields, orchards)	Arable land, urban, residential mixed	About 1/2 urban, residential mixed	1/2 or more urban, residential
Land use in flood plains beyond river levee	State of nature without artificial vegetation, manmade structures	Arable land or artificial vegetation	Artificial vegetation or natural vegetation mixed	About 1/2 park facilities, playground facilities	Impervious man-made structures, parking, etc.
Transverse direction of artificial structures	Absent	Bypass reservoir or slope waterway reservoir	Fish migration reservoir	Reservoir of height 0.3-0.4 m, fish migration difficulty	Fish move completely blocked
Sleep width /river width ratio	20% or more	20 ~ 10%	10 ~ 5%	5 ~ 1 %	Less than 1%

Table 3. River structure of the tributary of Seongdong River

Region	No. of flexion	Transversal & longitudinal sandbars	Diversity of flow	Bed materials	Diversity of low channel width	Materials of river shore at low channel width	Materials of river levee at low channel width	Mean
Upper	4	4	2	2	4	2	1	2.71
Middle	5	5	2	3	3	2	2	3.14
Low	4	5	4	4	2	5	3	3.86

Table 4. Index of degree of river naturality according to the environment of river at the tributary of Seongdong River

Region	The law water's edge vegetation	Flood way vegetation	Land use in riparian zones within river levee	Land use in flood plains beyond river levee	Transverse direction of artificial structures	Sleep width /river width ratio	Mean
Upper	1	2	1	1	1	1	1.17
Middle	3	3	2	3	1	2	2.33
Low	5	4	1	5	1	2	3

Table 5. List of vascular plants at the tributary of Seongdong River

Family	Species	Region			
		Upper	Middle	Low	
Equisetaceae	*Equisetum arvense* L.	○			
Ginkgoceae	*Ginko biloba* L.	○			
Pinaceae	*Pinus densiflora* S. et Z.	○			
	Pinus rigida Mill.	○			
Salicaceae	*Salix gracilistyla* Miq.	○			
Fegaceae	*Quercus acutissima* Carruth.	○			
Moraceae	*Morus alba* L.	○			
Cannabinaceae	*Humulus japonicus* S. et Z.	○	○		
Polygonaceae	*Persicaria hydropiper* (L.) Spach.	○			
	Rumex acetocella L.		○	○	NAT
	Rumex acetosa L.		○		
	Rumex crispus L.		○		NAT
	Rumex conglomeratus Murr.		○	○	NAT
Chenopodiaceae	*Chenopodium album* var. *centrorubrum* Makino		○	○	
	Chenopodium ficifloium Smith		○		
Phytolaccaceae	*Phytolacca americana* L.	○	○		NAT
Portulacaceae	*Portulaca oleracea* L.		○		
Caryophyllaceae	*Pseudostellaria heterophylla* (Miq.) Pax.	○		○	
Ranunculaceae	*Ranunculus japonicus* Thunb.			○	
Cruciferae	*Brassica campestris* spp. *napus* var. *nippo-pleifera* Makino		○	○	
	Capsella bursa-pastoris (L.) Medicus		○		
	Lepidium apetalum Willd.		○		NAT
	Lepidium virginicum L.	○			NAT
	Rorippa indica (L.) Hiern		○	○	
	Thlaspi arvense L.			○	NAT

Rosaceae	*Duchesnea chrysantha* (Zoll. et Morr.) Miquel	○			
	Potentilla fragarioides var. *major* Max.	○			
	Rosa multiflora Thunb.	○			
Leguminosae	*Amorpha fruticosa* L.		○		NAT
	Amphicarpaea edgeworthii var. *trisperma* Ohwi	○			
	Kummerowia striata (Thunb.) Schindl.		○		
	Robinia pseudo-acacia L.	○			
	Pueraria thunbergiana Benth.	○	○		
	Trifolium pratense L.	○		○	NAT
	Trifolium repens L.	○	○	○	NAT
Violaceae	*Viola mandshurica* W. Becker	○			
Onagraceae	*Oenothera odorata* Jacq.	○		○	NAT
Oleaceae	*Forsythia koreana* Nakai	○		○	
Plantaginaceae	*Plantago asiatica* L.	○	○	○	
Caprifoliaceae	*Lonicera japonica* Thunb.	○			
Compositae	*Ambrosia artemisiifolia* var. *elatior* Descourtils			○	NAT
	Artemisia princeps Pampan.		○		
	Aster ciliosus Kitamura	○	○	○	
	Bidens bipinnata L.	○	○		
	Cirsium japonicum var. *ussuriense* Kitamura		○		
	Conyza canadensis L.			○	NAT
	Cosmos bipinnatus Cav.		○	○	NAT
	Erechtites hieracifolia Raf.			○	NAT
	Erigeron annuas (L.) Pers.		○	○	NAT
	Taraxacum officinale Weber		○		NAT
	Xanthium strumarium L.		○	○	NAT
Gramineae	*Cyperus amuricus* Max.		○	○	
	Cyperus iris L.		○	○	
	Miscanthus sacchariflorus Benth.	○	○		
	Miscanthus sinensis var. *purpurascens* Rendle			○	
	Setaria viridis (L.) Beauv.		○	○	
	Zoysia japonica Steud.			○	

NAT: Naturalized plants.

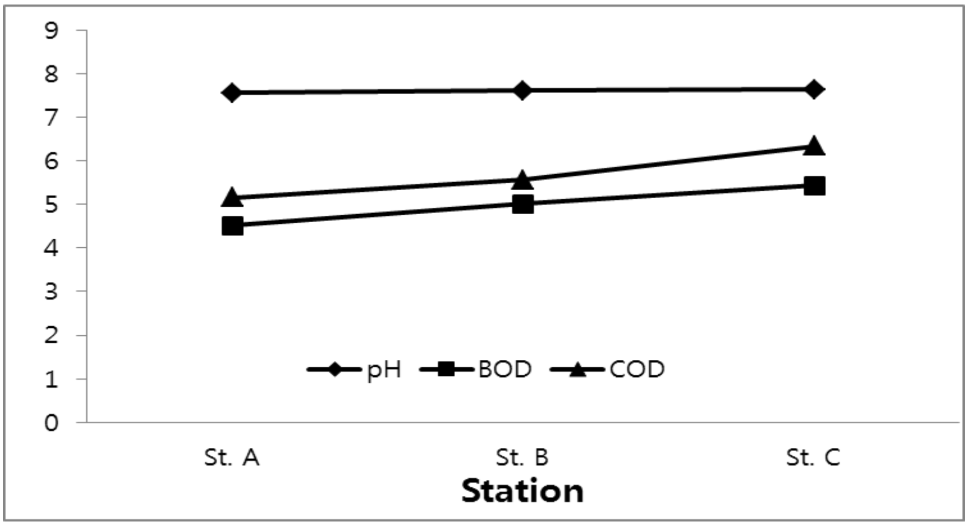

Figure 2: Water quality at three stations of three regions in the studied areas.

Table 6. Ecological distance (upper diagonal) based on Bray-Curtis' formulae analysis and geographic distances (low diagonal) among three stations

Station	St. A	St. B	St. C
St. A	-	0.811	0.942
St. B	0.226	-	0.527
St. C	0.539	0.238	-

IV. Discussion

The natural systems concept in river ecology is key to watershed management because it emphasizes that a watershed, as a natural system, is more than just a variety of natural resources coincidentally occurring in one place. Severely degraded watersheds may have lost several of their components and functions and provide fewer benefits to human and natural communities as a result. Thus it is clear that recognizing the natural system and working toward protecting the system's critical components and functions are key to sustainable watershed management [14]. In recent years the deterioration of vegetation formations around the upper and middle regions of the tributary of Seongdong River has increased at an alarming rate. Activities such as clearing forests for construction of factories, houses, and building roads can put too much soil and particulate matter in rivers. Suspended solids or suspended sediments are a natural component of the physical and chemical characteristics of the river. If they exceed the normal quantities, this may generate serious problems in the river corridor. Their high concentration and continuous impact may lead to asphyxiation of wildlife that use gills for respiration such as fish, invertebrates, larvae of amphibians, and fish eggs. Thus, the oxygen-demand parameters COD and BOD were within unacceptable levels at low regions (Fig. 2). The portion of BOD and COD in the river increased

exponentially along the upper-down gradient. This artificial action reduced the water's natural filtration action. Riparian area is the transition area between water and land regions [15].

As rivers and streams are patchy and strongly hierarchical systems, a hierarchical patch dynamics perspective can be used as a framework for visualizing interactions between structure and function in fluvial landscapes [16]. The perspective is useful for addressing fundamental attributes of river morphology as well as lotic ecosystems, such as heterogeneity, hierarchy, directionality and process feedback occurring across spatial scales and for illustrating spatio-temporal linkages between disparate concepts in river ecology.

V. Conclusions

This study is to investigate the degree of river naturality according to the river morphology, the degree of river naturality, the flora and vegetation on the tributary of Seongdong River at three regions during four seasons. The deteriorations of vegetation formations are a major cause of reduced river health in the Seongdong River. Although the riparian vegetation is developed at three regions in this river, the problem of water pollution may be serious.

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